



RF Radiation: Issues & Myths

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Some definitions ...

- ❑ Issue – a matter that is in dispute between 2 or more parties.
- ❑ Myth – a popular belief that has grown up around a particular source of or exposure to RF radiation; however, the belief is based on hearsay and conjecture and is without scientific merit.



These are issues, but are they myths, too?

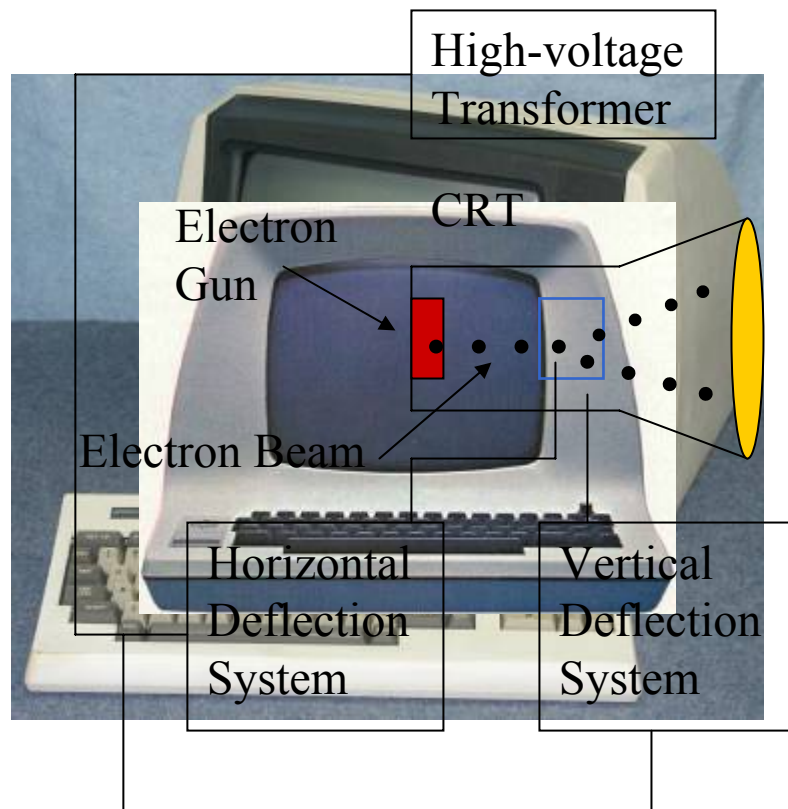
- ❑ Video display terminals adversely affect reproductive health of women.
- ❑ Abdominal exposure to 10-GHz radar was responsible for death of a worker.
- ❑ Exposure to microwave radiation from police radar causes testicular cancer.



And, these ...

- ❑ Chronic exposure to low-intensity microwave radiation from radar causes health effects.
- ❑ Exposure to cell-phone RF radiation is associated with brain cancer.

Video Display Terminal (VDT)



- ❑ Component of information processing equipment
- ❑ Cathode ray tube (CRT) device
- ❑ Electron beam steered by internal magnetic fields
- ❑ Horizontal scan at LF & VLF frequencies



Concerns about Radiation from VDTs

- Began around 1970 with concerns with x-ray exposure
- Eventually spanned decades as concerns moved from x-rays thru spectrum to static E-fields
- RF issues surfaced in mid-1970's
 - 1st NIOSH evaluation published in 1977



Concerns with Health Effects from VLF-RF Exposure

- Cataract formation
- Reproductive effects
 - Spontaneous abortion
 - Miscarriages
 - Birth defects
 - Arose from reported “clusters” of effects



Became World-wide Issue Fueled by...

- ❑ VLF Measurement problems
- ❑ Limitations of exposure assessment in epidemiology studies
- ❑ Entrepreneurs: screen shields, enclosures, etc.



VLF Measurement Problem

- Out-of-band response
 - NIOSH 1977: E & H instruments' frequency range: 10-500 MHz
 - VDTs emission range: 10-250 kHz

- Capacitive coupling
 - Antenna elements used too close to fly-back transformer produce meaningless data.



National Research Council

- “Early press accounts of such erroneous readings had led to unwarranted concerns about a potential hazard from RF emissions.”

Video Displays, Work and Vision
National Academy Press, 1983



Meaningful Measurement Data

- ❑ United States, Canada, England, Australia, Japan, Yugoslavia, Italy, Germany, Finland, Sweden
- ❑ de facto measurement distance = 30 cm
- ❑ No overexposures were reported.
- ❑ Limit: ACGIH guideline



Epidemiology

- Exposure assessment metric: VDT use
- Example: Kaiser-Permanente study
 - Case-control study of 1583 pregnant women
 - Questionnaire or telephone interview
 - $OR = 1.8$ (95% CI = 1.2-2.8) for miscarriage with VDT work > 20 h/wk
 - OR not significantly elevated for miscarriage (any work with VDT) or birth defects



NIOSH Study: Schnorr et al. 1991

- ❑ Cohort study: 323 exposed & 407 controls
- ❑ Measurement data: randomly selected work stations
- ❑ Duration of exposure: company records
- ❑ Reproductive history: telephone interview
- ❑ No significant differences in live births, still births, & spontaneous abortion



The diminishing of an issue ...

- Swedish Board for Technical Accreditation
 - SWEDAC standards for low-radiation monitors
 - Based on what is technically achievable, not health effects

- Some resistance from US manufacturers
 - Some sold low-EMF monitors in Europe & existing technology in US – to make a point!



The diminishing of an issue ...

- New technology
 - Commercially viable flat panel displays
 - Liquid crystal displays (LCD)
 - Units actually have a higher E-field strength than CRT-type VDTs

Classification:



□ Myth-like qualities

- All measurements <<EL
- Penetration depth for cataracts
- Relative permeability for H field interaction
- Measurement & epidemiology limitations
- ID: Clusters

□ Issue-like qualities

- Unique waveform
- Penetration depth for reproductive effects
- Little known about VLF/LF bioeffects in 1977
- ID: Clusters



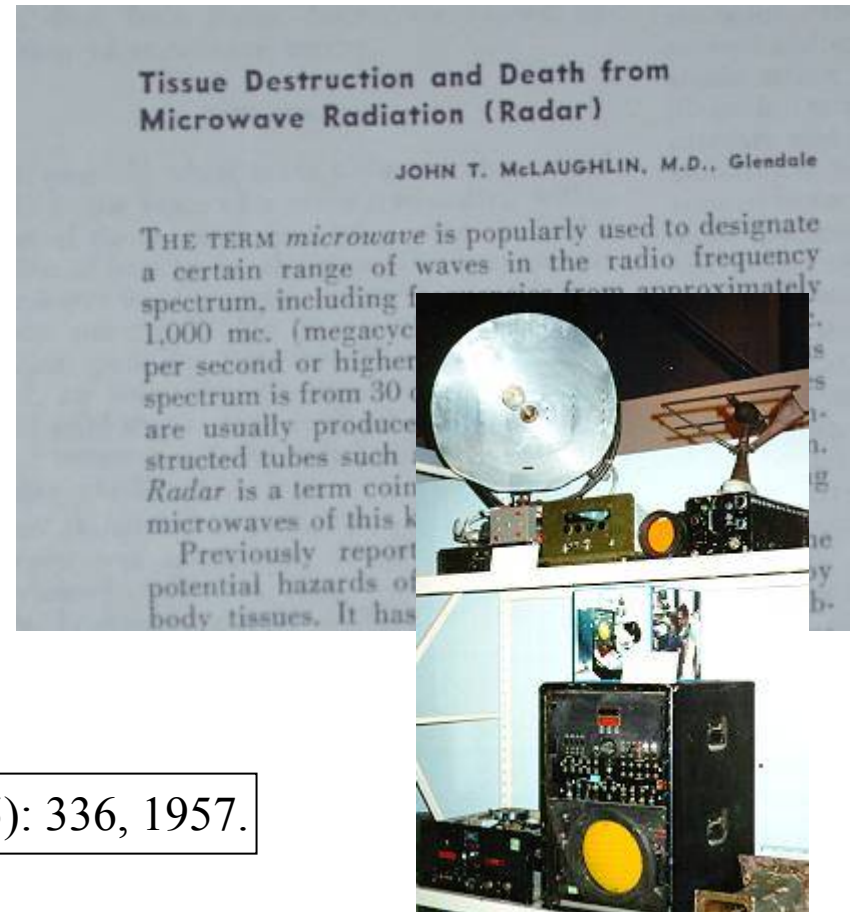
Radar Issues & Myths?

- ❑ Tissue destruction & death
- ❑ Police radar & testicular cancer
- ❑ PAVE PAWS & public concern

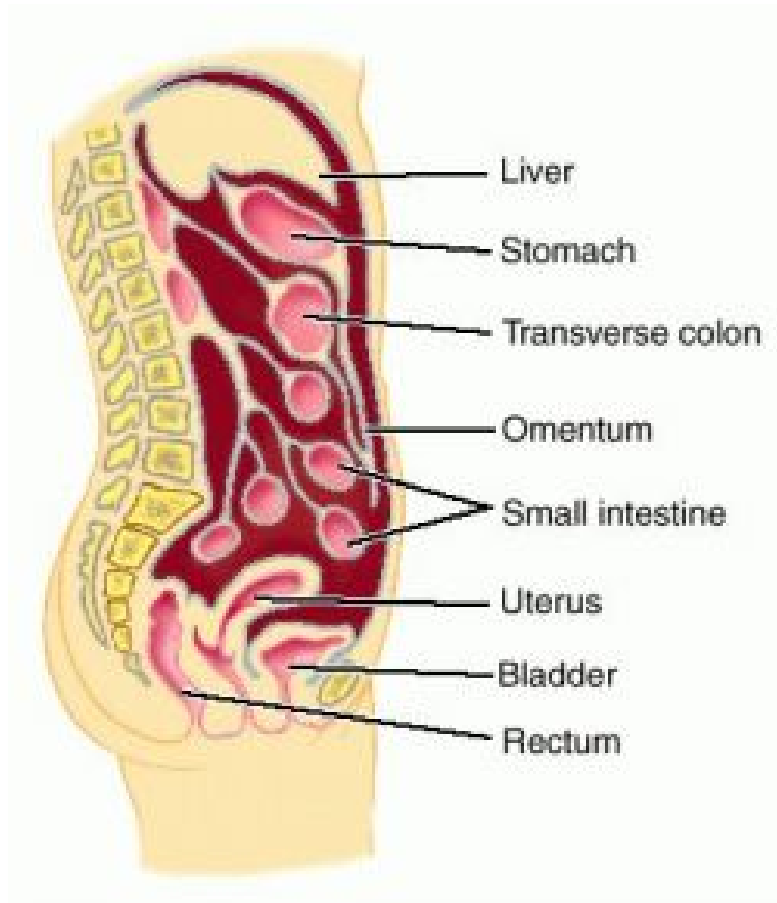
Radar: Tissue Destruction & Death

- ❑ 42-year old man
- ❑ “...stood directly in the beam of a radar transmitter, within ten feet of the antenna.”
- ❑ “...sensation of heat... [which] “became intolerable...”

Calif. Med. 86(5): 336, 1957.



Tissue Destruction & Death



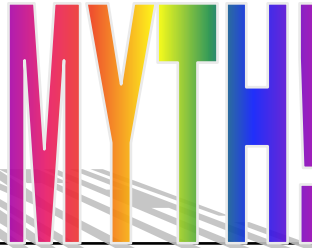
- ❑ Symptoms consistent with acute peritonitis
- ❑ No skin damage reported
- ❑ Appendix gangrenous
- ❑ Postmortem exam: enteritis & “...cooked, hemorrhagic appearance of small bowel...”



Thomas S. Ely, M.D.

- ❑ Source: 10-GHz microwave
- ❑ Penetration depth into tissue is shallow.
- ❑ EM energy is absorbed as it penetrates.
- ❑ “To injure an organ in the abdominal cavity it would first be necessary to burn away the abdominal wall.”

Classification:



□ Myth-like qualities

- Penetration depth & attenuation
- Undamaged skin with internal injuries

□ Issue-like qualities

- Armed Services Institute of Pathology incident report
- Not unique exposure

Police Radar & Testicular Cancer

- ❑ Anecdotal reports appeared in reports & magazines.
- ❑ In some states, highway patrolmen stopped using radar.



Police Radar Units

- ❑ Frequencies: 10.5, 24 & 35 GHz
- ❑ Measured exposures ($<1 \text{ mW/cm}^2$) were lower than exposure guidelines (5 or 10 mW/cm^2).

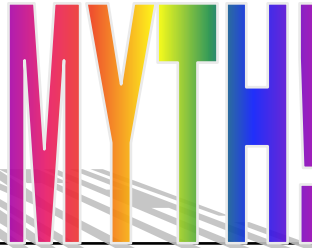


Epidemiology: Testicular Cancer

Design	Study Group	Findings
Cohort	Evaluation of a cluster; 6 subjects Davis & Mostofi, AJIM 24:231 (1993)	Significant number of observed cases vs. expected
Cohort	22,197 Ontario police officers Finkelstein, AJIM 34:157 (1998)	Slight, non-significant increase in risk

Other studies have evaluated testicular cancer & microwave exposure in the workplace, but not specifically for policemen.

Classification:



□ Myth-like qualities

- Measurement data <<EL
- Measured levels would not produce significant heating in testes
- Anecdotal reports

□ Issue-like qualities

- Penetration depth
- Elevated temperature can affect testes



PAVE PAWS & Public Concern

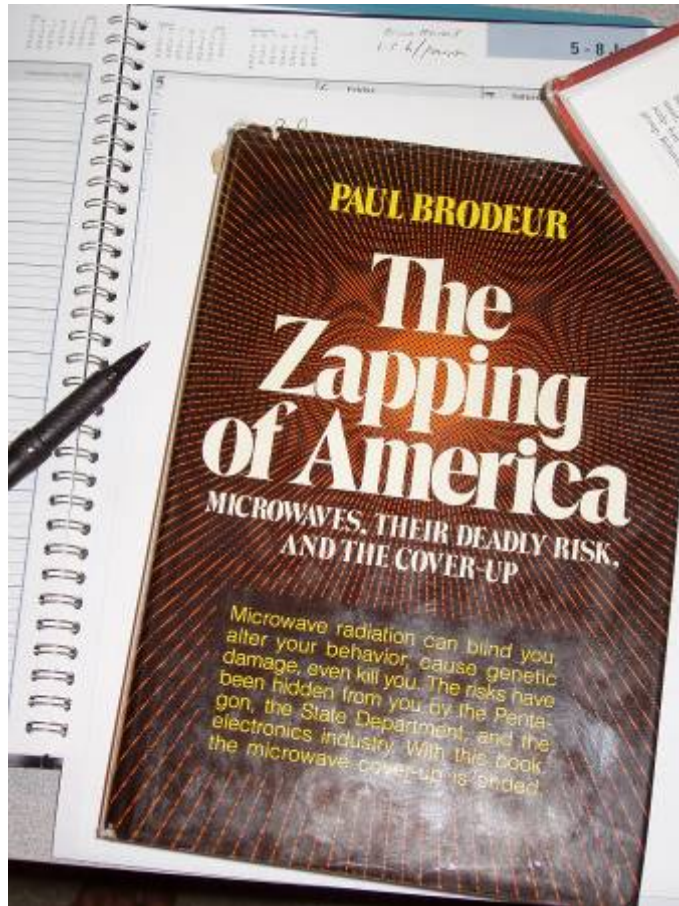
- ❑ Phased Array Warning System
- ❑ Part of US Air Force Space Command
- ❑ Located on upper Cape Cod, MA
- ❑ Purpose
 - Detect & track sea-launched and ICB missiles
 - Track earth satellites

PAVE PAWS Characteristics

- ❑ 420-450 MHz
- ❑ 1792 active elements
- ❑ 325 watts per element
- ❑ 22.1 m diameter (active radar)
- ❑ Exclusion fence @ 305 m
- ❑ 20 degree face tilt
- ❑ 60% of energy in main beam



Protests Began in 1977



- ❑ Meetings between public & USAF
- ❑ Much press coverage
- ❑ Concern about thermal effects of exposure
- ❑ Questions arose about US exposure guidelines vs. substantially lower Soviet limits



National Research Council

- Report published in 1979
- Estimated exposure to general public
 - 100 $\mu\text{W}/\text{cm}^2$ – maximum
 - 1 $\mu\text{W}/\text{cm}^2$ – time-averaged
- “...no known irreversible effects of such exposure on either morbidity and mortality in humans or other species.”



However, concerns persisted...

- ❑ Possible biological relevance of waveform
- ❑ Concerns about time delay of emission including sidelobes
- ❑ Uniqueness of PAVE PAWS radiation may render existing safety standards inadequate

2005 NRC Report



- ❑ Waveform similar to that of dish antennas used for radar and SATCOM

- ❑ Estimated exposure to general public
 - Consistently $< 0.1 \mu\text{W}/\text{cm}^2$
 - Range: $0.001 - 0.01 \mu\text{W}/\text{cm}^2$
 - Highest: $15 \mu\text{W}/\text{cm}^2$ (elevated locations)




Conclusions on Possible Health Effects

- ❑ Increasing duration of exposure has not resulted in increased incidence of cancer.
- ❑ “...no adverse health effects to the population resulting from continuing or long-term exposure to the PAVE PAWS radiation.”



Conclusions on Possible Health Effects

- ❑ No risk of cancer, reproductive/developmental effects or neurobehavioral effects
- ❑ Based on review of animal studies
- ❑ Relevance of some biological changes is not known or may have no impact on health



Epilogue ...it's not over yet!

- ❑ Epidemiology study has been performed by the International Epidemiology Institute.
- ❑ 2006 – NRC panel reviewed results of final draft of epidemiology study
- ❑ Final report not published yet

Classification:



□ Myth-like qualities

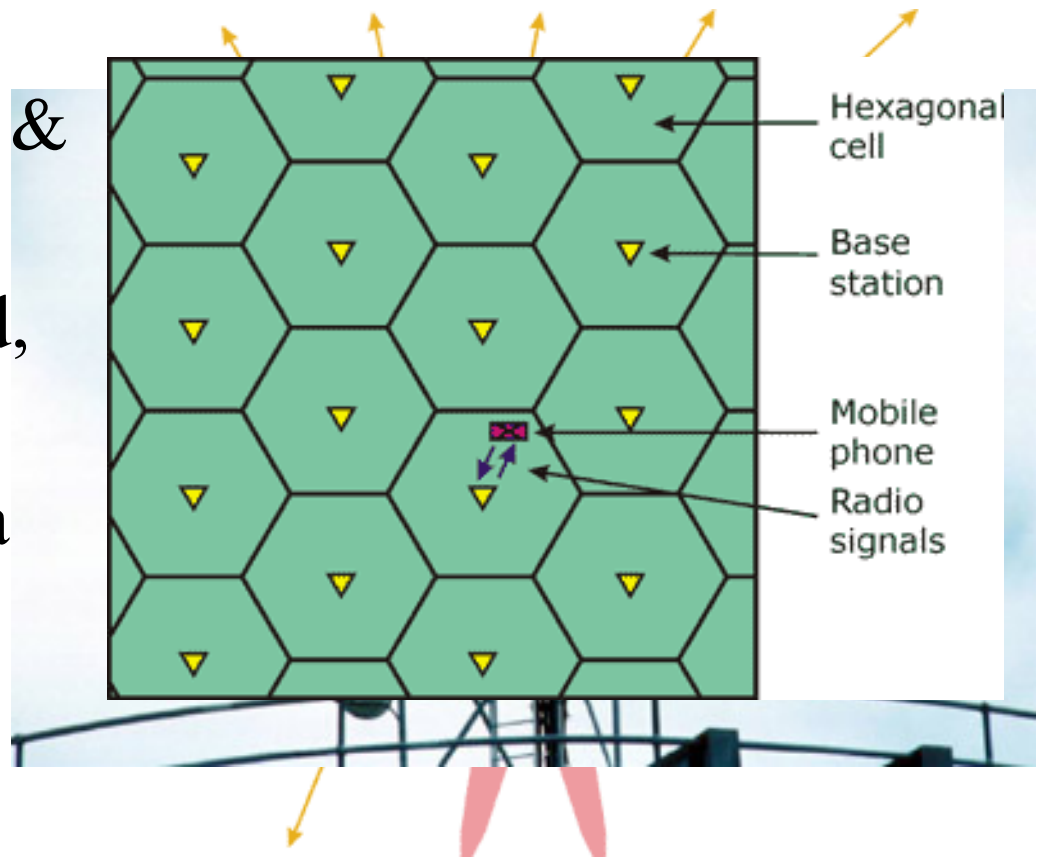
- All measurements <<EL (1979, 2005)
- Thermal effects not expected at measured levels (1979)
- Speculative mechanism (2005)
- Unique waveform (2005)

□ Issue-like qualities

- Lack of information / response by USAF
- Waveform not unique (2005)
- Increased risk rates in cancers in upper Cape Cod communities
- Involvement of National Research Council

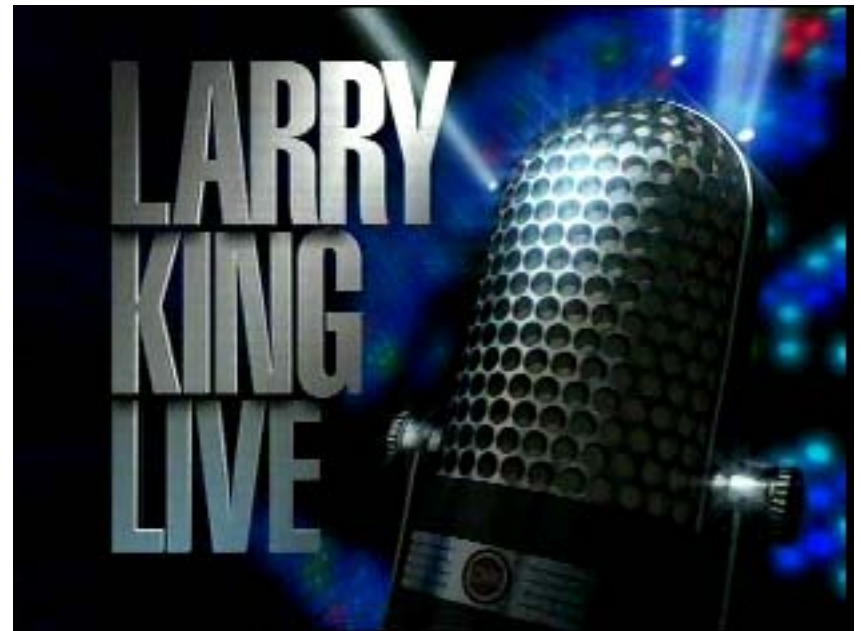
Cell Phones & Brain Cancer

- ❑ Exposures: UHF radiation from phone & base station
- ❑ Base station: elevated, 2-way radio
- ❑ Area covered called a cell



How it began ...

- ❑ Issue surfaced on Larry King Live in 1993
- ❑ Individual law suit against cell phone manufacturer & service provider
- ❑ Basis: wife's death from brain cancer



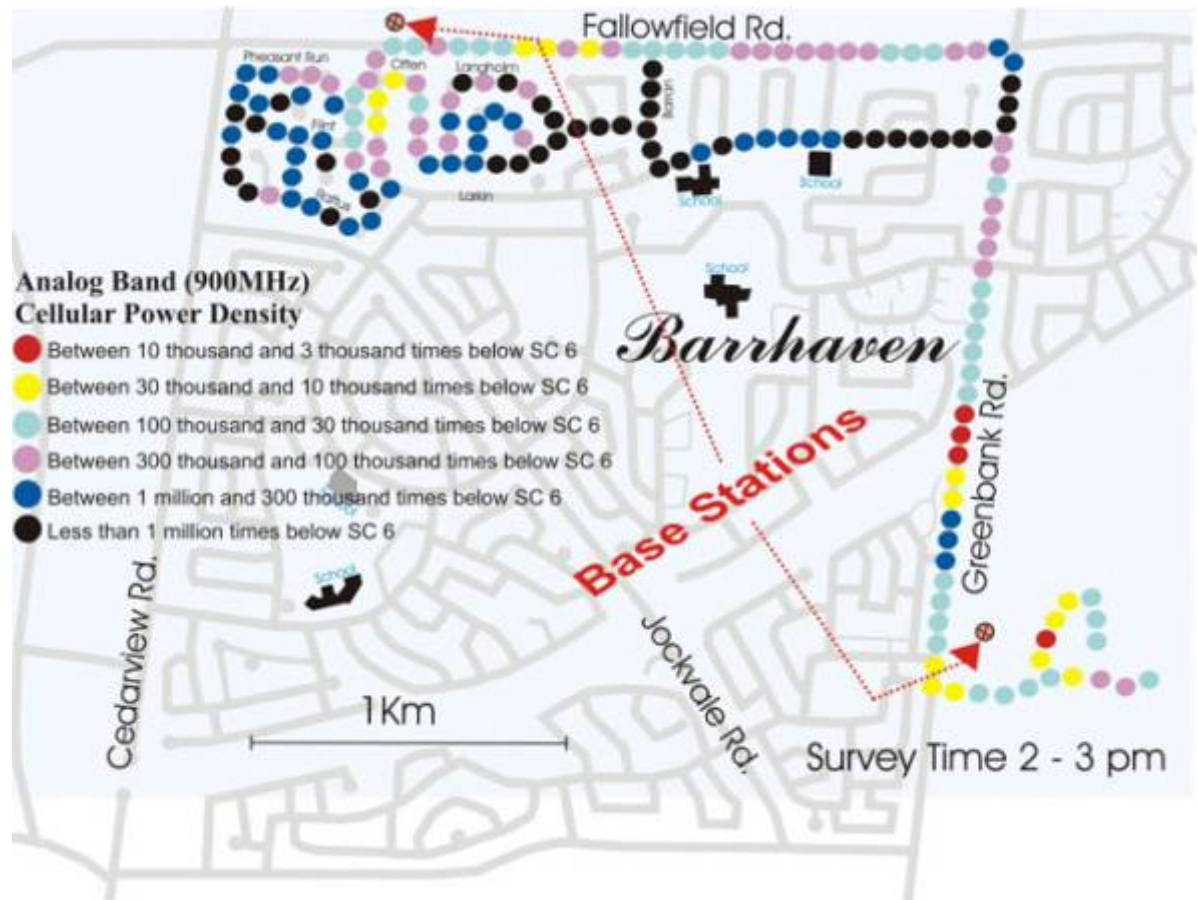


Cellular Telecommunications Industry

- ❑ Not prepared for ensuing controversy
- ❑ Studies of exposure to cell-phone radiation were non-existent.
- ❑ Industry-sponsored literature review
 - Included many animal studies of 915 & 2450 MHz (microwave oven/dryer frequencies)
 - No relevant dosimetric or human studies

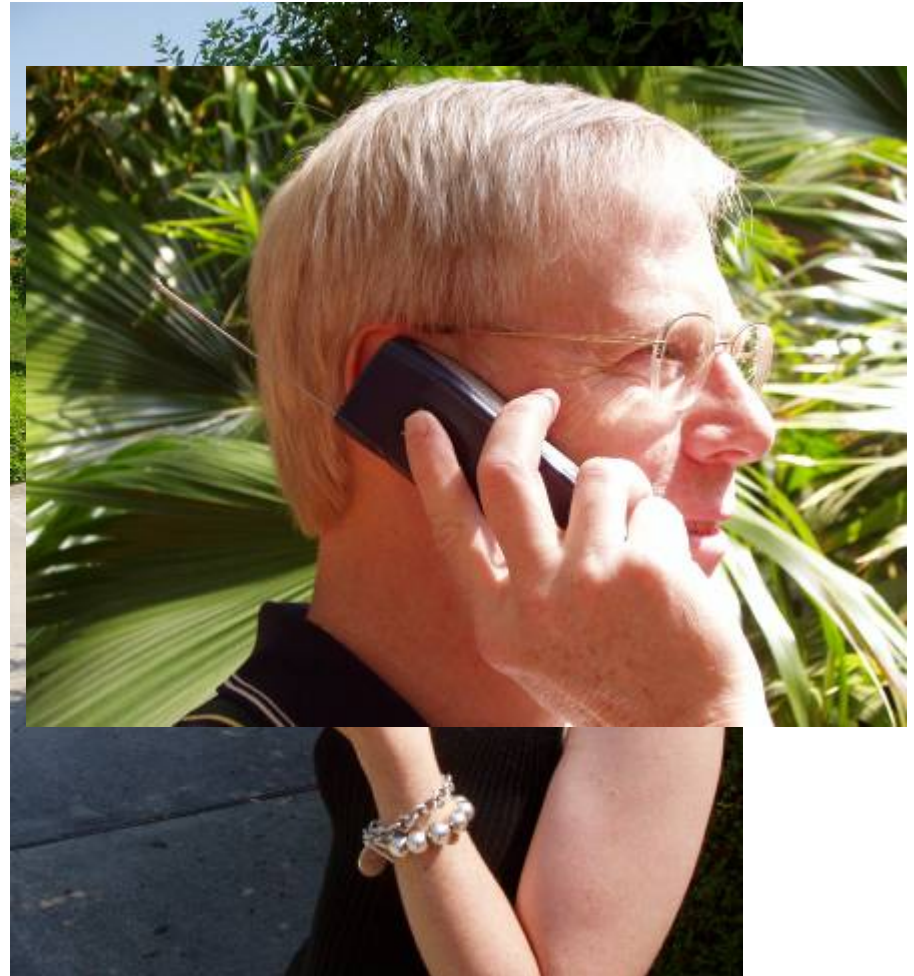
What about exposures?

Base Stations
Measured levels
< 1% EL

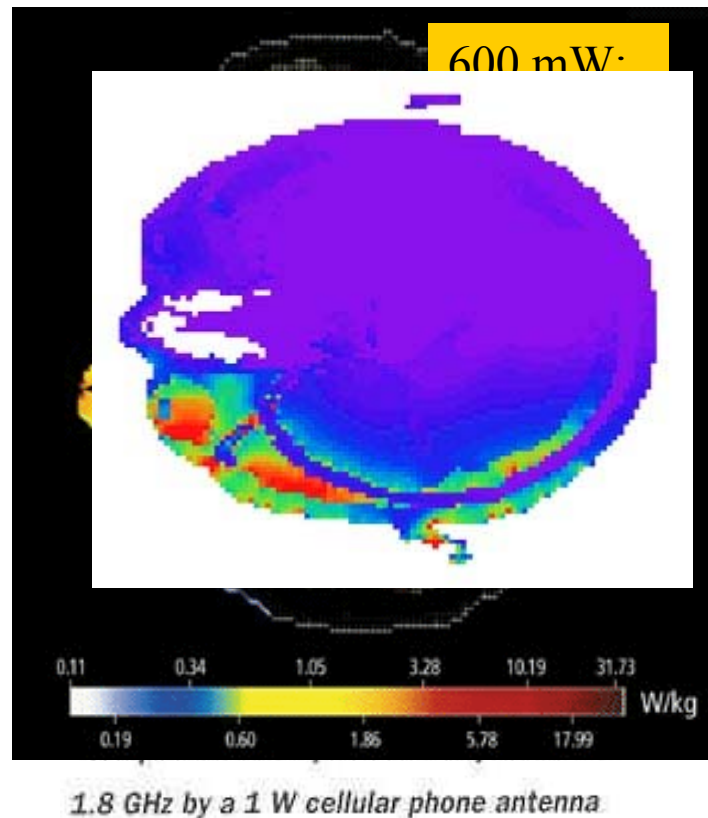


Determinants of Exposure (Local SAR)

- ❑ Frequency
- ❑ Handset geometry
- ❑ Orientation of antenna
- ❑ Size / shape of head
- ❑ Antenna type / size
- ❑ Local SARs may be \geq EL



Dosimetry: Local SAR



- SAR determined in physical & computer models of head
- RF energy localized to side of head exposed
- Pinna highly exposed
- Ocular exposure demonstrated, too.



Health Effects' Studies

- *In vitro* – genotoxicity; searching for a mechanism
- *In vivo* – cancer & CNS; relatively few studies
- Humans – experimental & epidemiologic



Human Cancer Studies

- Designs: case-control, cohort, ecological
- End points: all, brain, acoustic neuroma, salivary, ocular melanoma, leukemia



Human Cancer Studies - Results

- Brain cancer not reliably affected

- Examples: positive & negative findings for
 - Analogue phone use
 - Glioma
 - Laterality
 - Acoustic neuroma

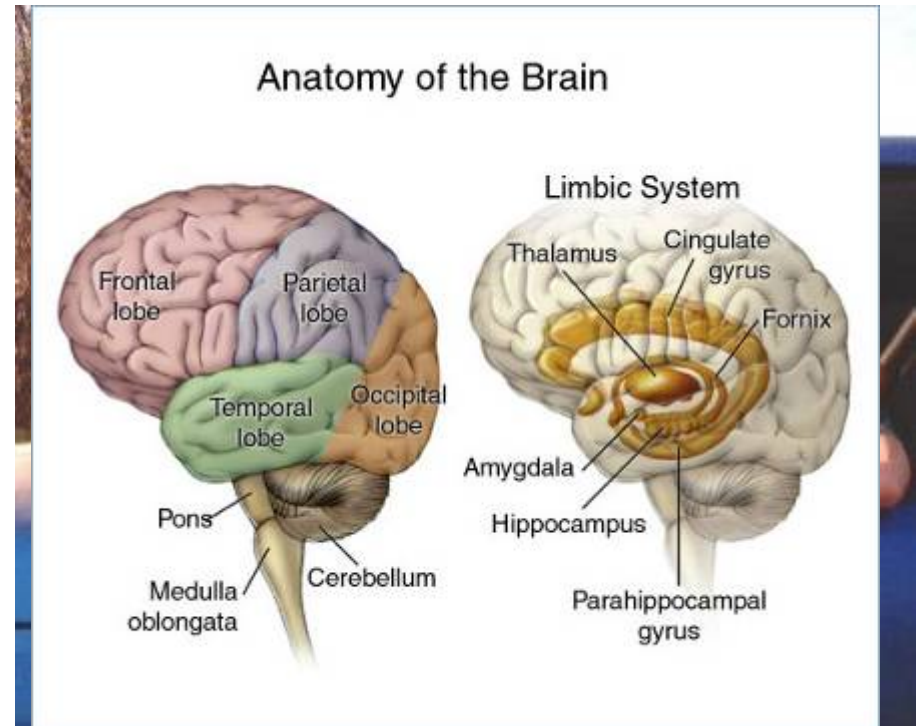


Studies with Test Animals

- One statistically significant finding
 - 900 MHz, 0.01-4.2 W/kg, transgenic (lymphoma-prone) mice, increase in all lymphomas & non-lymphoblastic lymphomas
- Not replicated; other studies observed no statistically significant differences between exposed & control animals

Waiting with baited breath ...

- ❑ Interphone study
- ❑ 13 European countries using stylized methods
- ❑ Many countries have reported study results
- ❑ Overall findings & dosimetric results not published, yet



Classification:



□ Myth-like qualities

- No known mechanism for effect
- Low operational power
- ID: individual with litigation

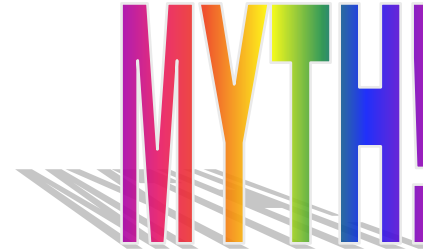
□ Issue-like qualities

- Some measurement data indicate potential for overexposure
- Penetration depth can reach target tissue
- Unique exposure – near field with modulation

Summary



- ❑ VDTs & reproductive health
- ❑ Cell phones & brain cancer
- ❑ PAVE PAWS & public concern



- ❑ Radar: tissue & death
- ❑ Police radar & testicular cancer